3. FAA R&D Goals, Objectives, Challenges, and Strategies

As shown in the Figure 3-1, the FAA has developed a strategic framework to ensure that R&D activities remain focused on the agency's mission goals. Those goals are subdivided into specific **Derived Goals** that represent the critical outcomes central to achievement of the mission goals. Each Derived Goal is then further subdivided into one or more specific and potentially measurable **Performance Objectives**, each of which addresses a different aspect of the Derived Goal. In general, achievement of each Performance Objective will depend upon knowledge, tools, technical advances, or other research products, and thus implies a specific **R&D Challenge** to be met by the FAA R&D program. With the R&D Challenges thus defined, specific **R&D Strategies** are developed to meet them. The strategies are realized through the development and performance of the projects that comprise the FAA R&D program.[8]

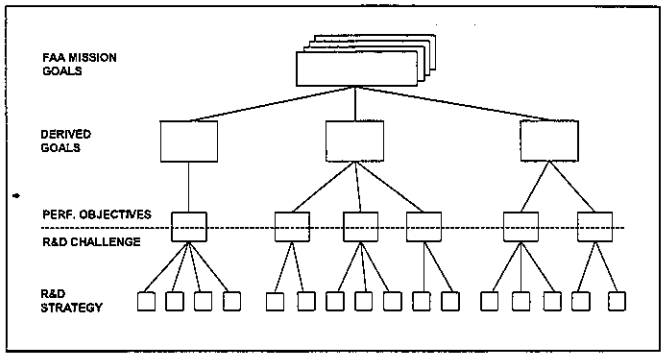

Figure 3-1 Goal-Performance Objective-Strategy Hierarchy, Showing Links to R&D Program

These Derived Goals, Performance Objectives, R&D Challenges, and R&D Strategies will shape and guide FAA research activities during the next 5 years, subject to refinement based on agency and aviation system needs and interim R&D findings. Cumulatively, implementation of these cross cutting strategies will provide the research products necessary to meet agency goals.

Safety

Derived Goals

The FAA safety goal is to reduce fatal accidents in both commercial and general aviation. Accidents can be prevented by establishing and maintaining a broad framework of regulations and standards, developing a better understanding of accident causes and countermeasures, introduction of new technology, and leading and participating in cooperative programs with the aviation community. These activities enhance safety in three ways: (1) identification and prevention of accidents due to emerging or previously unrecognized causal factors; (2) reduction of the recurrence of accidents associated with known causes (e.g., weather, human error); and (3)

[8] Details of the projects that comprise the full R&D program can be found in the annual FAA *National Aviation Research Plan,* the FAA budget submission, and other FAA planning documents. This strategy document has a 5-year perspective. The specific strategies are intended to guide evolution of the R&D program over that time frame, and, therefore, are not necessarily fully realized in current research activities.

protecting passengers and crew by mitigating the consequences of a crash or in-flight incident, thereby increasing survivability. These approaches are reflected in three derived goals:

- ***Reduce the occurrence of aviation system accidents caused by new or previously unrecognized factors.***
- ***Reduce the recurrence of aviation system accidents due to known risks or causal factors.***
- ***Increase the survivability of aviation system accidents and incidents.***

Modern aviation is also vulnerable to attacks involving communication, navigation, and other information technology, electronic, and software-based systems. At a NAS-wide level, successful attacks of this nature could pose a serious threat to passengers and crews, and an extended disruption or shutdown of air transportation would be most serious. Hence, a fourth derived safety goal is to:

- ***Prevent successful attacks on the integrity and availability of critical NAS-information systems.***

Finally, there is increasing recognition of the potential for a variety of long-term health effects on transport aircraft passengers and flight crews. Assessment of the level of risk and the value of alternative countermeasures is implicit in the FAA safety mission, leading to an additional derived safety goal:

- ***Prevent adverse health impacts on air passengers and flight crews.***

Performance Objectives, Challenges, and R&D Strategies

Derived Goal: Reduce the occurrence of aviation system accidents caused by new or previously unrecognized factors.

Performance Objective: Reduce hazards by developing increased aviation community knowledge and understanding of current operations and potential accident causes.

R&D Challenge: *Safety Information Sharing and Analysis* - Develop and apply data and analytical tools for use by FAA and industry in identifying potential accident causes and developing effective safety programs and countermeasures.

Many hazardous conditions can be identified, and preventive actions taken, by exploiting the means now available for monitoring and analyzing flight operations on a large scale. However, for this approach--implemented in collaboration with the entire aviation community--to obtain the level of success that is potentially possible, substantial advances are needed in the availability of analytical tools. Comprehensive analyses are also required with accompanying special efforts to incorporate the results in safety programs.

R&D Strategies:

1. Develop and apply data systems and risk management and decision support tools and methodologies to monitor and analyze the aviation system operations and safety risks that encompass air carriers, aircraft design, aircraft maintenance, aviation training schools, and personnel.

2. Develop a broadened understanding of biomedical, toxicological, and human performance factors that can contribute to accidents through research studies and results of FAA's role in performing toxicological and other biomedical analyses for aviation and other transportation accidents.

Performance Objective: Prevent any degradation of safety associated with the introduction of new technologies, operational practices, or other changes in the global aviation enterprise.

R&D Challenge: *System Safety and Risk Management* - Develop and apply knowledge and analytical tools to assess the safety implications of innovative technologies and operational procedures planned or proposed for implementation in the airspace system.

The NAS is increasingly interconnected and automated, and relies on software for many safety-critical functions. Tools will be evolved that will assist and enhance human design and analytic capabilities, support human reasoning about the properties of complex systems, and lead to efficient creation of more robust and trusted systems. Application of advanced technologies, particularly communication, navigation, and surveillance (CNS) and automation, will enable new and evolving operational concepts, procedures, and allocation of responsibilities for operational use in the NAS.

Although new technologies and procedures are intended to improve the safety, security, efficiency, and environmental compatibility of the airspace system, it is always possible that a particular change or innovation could interact with other system elements in ways that could increase risk. One example is increased reliance on digital software-based aircraft systems, which will increasingly require additional or revised certification criteria be developed and updated. To prevent any degradation of safety in this process, a system safety perspective needs to be incorporated throughout civil aviation. Only in this way can potential adverse interactions and incompatibilities among the system elements, training, equipment, maintenance practices, etc., be detected and countermeasures be developed before an accident occurs.

R&D Strategies:

1. Develop tools to support the efficient design, development, validation, production, and certification of high confidence software and systems in safety-critical NAS functions and aircraft avionics. Develop knowledge and tools to facilitate the ability to assess and develop certification criteria for the continually expanding use of digital software-based aircraft systems.

2. Assess and develop responses to the safety implications of the greater use of new composites, alloys, and other materials, and associated structures and fabrication techniques. Develop a

comprehensive understanding of the aging process and failure modes associated with the incorporation of new materials into aircraft structures and systems, and of appropriate maintenance and inspection practices, to assure that the potential for improved performance and cost characteristics is not accompanied by any degradation of safety, and that opportunities for safety enhancements are fully exploited.

3. Assess and address the safety implications of evolving operational procedures and practices, specifically including potential impacts of measures to enhance aviation security. Detailed examination of failure modes, anomalous situations, human performance considerations, and other safety-related matters will be conducted in close partnership with industry.

Derived Goal: Reduce the recurrence of aviation system accidents due to known risks or causal factors.

Performance Objective: Reduce the number of accidents associated with weather, icing conditions, and other aspects of the flight environment.

R&D Challenge: *Hazards of the Flight Environment* - Characterize potential hazards of the flight environment and develop the knowledge base and technologies needed to eliminate or reduce those hazards.

A variety of hazards exist in the flight environment, producing threats to aircraft safety even in the absence of any equipment malfunction or human error. Severe weather is the most common of these hazards. Flight crews must be aware of icing conditions and know countermeasures for mitigation of in-flight and ground icing. Turbulence, whether arising naturally or from the wake of aircraft en route or in terminal operations, can also pose a significant threat. In addition, other serious flight environment risks, such as electromagnetic fields from ground sources or passenger-carried sources, could conceivably cause malfunction of sophisticated and critical avionics equipment.

R&D Strategies:

1. Improve understanding, predictability, and the ability to deal with adverse weather, icing conditions, and other atmospheric hazards, and improve the delivery of weather products to pilots and aircrews. Conduct tests, perform analyses, and develop and apply more accurate algorithms that improve the clarity, specificity, and timeliness of weather information provided to traffic controllers, flight crews, general aviation pilots, and airline dispatchers.

2. Develop guidance concerning flight hazards associated with electromagnetic fields. Develop the means to characterize risks and protect aircraft electrical and electronic systems against the effects of lightning and high intensity radiated fields that may come from airborne, ship borne, and ground-based emitters, including portable electronic devices that may be carried aboard by passengers.

Performance Objective: Reduce the number of accidents associated with the failure of aircraft structures, components, and systems.

R&D Challenge: *Failures of Aircraft Structures and Systems* - Develop knowledge, criteria, tools, technologies, and practices to improve reliability and prevent or reduce failures of aircraft structures and systems.

Standard analysis and test methods, based in part on better understanding of failure mechanisms, are needed to support regulatory responsibilities in the area of aircraft structures and materials. It is important to incorporate new materials and associated structural design and construction practices that can reduce or eliminate known risks. Similar considerations arise in connection with the failure of turbine rotors, general aviation engines, and with issues related to aircraft fuels. Assurance of the continued airworthiness of aging aircraft requires information, technologies, techniques, and inspection systems to ensure the safe operation of aircraft electrical, mechanical, and fuel systems. A high level of understanding, as well as identification of possible regulatory actions or potential specific countermeasures, are needed in key areas of catastrophic failure, such as turbine engine uncontainment events, uncontrollable in-flight fires, fuel tank explosions, and other propulsion system malfunctions.

R&D Strategies:

1. Develop improvements in aircraft fuel tank explosion protection.

2. Develop knowledge, inspection tools, techniques, and strategies to address safety hazards associated with the aging of airframe structures, engine components, and mechanical and electrical systems.

3. Assess the use of improved processing and manufacturing techniques for critical engine components to eliminate engine failures

4. Assess the use of advanced materials to protect aircraft critical systems and passengers in the event of catastrophic engine failures.

5. Assess the safety implications of changes to aviation fuels used for both commercial and general aviation.

Performance Objective: Reduce the number of accidents associated with the performance of pilots and aircrews, controllers, maintainers, and others who fill roles important to the safety of the NAS.

R&D Challenge: *Human Performance* - Develop knowledge, guidance, and standards to improve the performance and structure the roles and working environments of the people who play critical roles in aviation safety.

Human error is frequently a contributing or causal factor in aviation accidents and incidents. Errors of this nature can arise from limitations of training materials and programs, design of displays and controls, fatigue, or sensory and cognitive impairment of individuals, as well as other issues relating to human behavior and performance. Improvements in all of these areas depend on availability of scientifically validated information and guidance concerning means of enhancing the performance of a wide range of people who play critical roles in aviation safety:

air carrier crews; general aviation pilots; aviation maintenance and inspection personnel; air traffic controllers; and NAS system maintenance specialists. Key interventions supported by human factors research include more effective training techniques, tools and materials; application of the principles of human-centered design to displays and controls; new or revised operational practices; and application of human factors considerations in certification of new aircraft and in equipment design and modification.

R&D Strategies:

6. Develop knowledge, guidance, and standards for the design and use of automated support systems. Develop and apply human factors concepts and guidelines in the design, development, evaluation, and certification of advanced-technology control and display systems for flight deck, air traffic control, and airway facilities applications to address issues associated with: workload; situational awareness (particularly in the context of using advanced automation equipment); recovery from automation failures; skill retention and dependency on automation; and alternative human-computer interfaces in aviation applications.

7. Develop and apply increased understanding of the relationship between human abilities and aviation task performance to:

   - Assess the appropriate knowledge, skills, abilities, and characteristics needed to excel in highly automated environments;

   - Develop guidelines for effective training materials and instructional delivery systems applicable to complex working environments;

   - Evaluate countermeasures to stressors (e.g., fatigue) that affect alertness and performance; and

   - Assess the impact of new technologies and operational circumstances (e.g., longer-duration intercontinental flights) on job characteristics and requirements, as well as on the associated consequences for selection and training.

8. Develop knowledge, guidance, and standards for human performance assessment. Identify the intrinsic characteristics of individuals and teams that determine how well they are able to perform aviation tasks, characterize the impact of environmental (external and internal) and individual factors on human performance, and improve and standardize methods for measuring human performance. Develop more effective methods for investigating, reporting, analyzing, and mitigating human error.

9. Develop knowledge, guidance, and standards for information management and display. Identify the most efficient and reliable ways to display and exchange information, determine what, when, and how one might best display and transfer information to system components, design the system to reduce the frequency of information transfer errors and misinterpretations, and minimize the impact when errors do occur.

10. Develop knowledge, guidance, and standards for bioaeronautical factors. Enhance personal performance and safety by enabling commercial aviation crews and general aviation pilots to better understand and become more aware of health and physiological integrity issues, including spatial disorientation, visual illusions, and hypoxia.

Performance Objective: Reduce aircraft accidents and incidents associated with air and ground operations on the airport surface and surrounding airspace.

R&D Challenge: *Terminal Area Safety* - Develop technologies and evaluate strategies to increase pilot and controller situational awareness in the terminal area, reduce wildlife interactions, and assure compatibility of airport designs and infrastructure with new types of aircraft.

Runway incursions continue to occur at an unacceptably high level. While serious accidents due to incursions have been rare in the United States, the potential for a catastrophic event has made this a high-priority program. Assurance of pilot and controller situational awareness is key to reducing these accidents. Aircraft and vehicle detection and alerting technologies and systems are important countermeasures, as are clear signs and markings to minimize the possibility of human error or misperceptions. Another growing concern in the terminal environment is the possibility of collision of aircraft with birds and other wildlife attracted by the favorable conditions often found near airports.

R&D Strategies:

1. Develop technology and standards to increase pilot, controller, and vehicle operator awareness of potential runway incursions and other airport surface traffic hazards:

    - Develop, evaluate, demonstrate, and validate–in an operational environment–advanced technology and systems for surface detection, secondary surveillance, conflict-alerting and data fusion, cockpit displays, and runway status lights to increase pilot and controller situational awareness; and
    - Develop and apply advanced light sources and applications, addressable signs, and ground marker communications, accompanied by development of a computer-based simulation system, to evaluate new visual guidance systems and procedures, particularly during low visibility conditions.

2. Conduct evaluations and assessments of means to reduce bird-strike and other wildlife-related risks. Develop effective means of habitat management to reduce bird activities around airports, and identify active and passive techniques that can reduce the presence of birds and other wildlife at airports.

3. Conduct tests and analyses to assure compatibility of airport design with new larger aircraft, particularly with respect to airport pavements and design, to assure that safety is not compromised as these aircraft come into common use.

Performance Objective: Prevent any threat to public health and safety in the testing, operation and use of Reusable Launch Vehicles (RLV).

R&D Challenge: *Safety of Reusable Launch Vehicles* - Determine best practices for commercial space transportation operations and develop criteria for assessing the safety of RLVs.

The potential for a significant increase in commercial space operations, particularly involving reusable launch vehicles, carries with it the responsibility for FAA to establish plans, regulations, guidance, and licensing approaches to assure the health and safety of the public. The safety of space launch and landing sites also needs to be addressed, including assurance of coordination with NAS operations.

R&D Strategies:

1. Identify best practices for commercial space transportation operations and maintenance. Analyze and assess standards and processes applicable to commercial RLV operations and maintenance activities to assure that they provide adequate public safety, with emphasis on applicability of relevant NASA and aircraft industry best practices.

2. Establish criteria to define a "proven" RLV. Develop criteria for a basic methodology to assist in determining when an RLV has progressed from "unproven" to "proven" status and for judging the public safety relevance of methodologies associated with proven RLVs.

3. Assess effects of RLV maneuverability characteristics on public safety. Increase understanding of safety issues regarding reentry of RLVs and reentry vehicles with respect to maneuverability of vehicles reentering from space and differentiation between maneuverable and non-maneuverable vehicles.

Derived Goal: Increase the survivability of aviation system accidents and incidents.

Performance Objective: Reduce the occurrence of aircraft fires and the consequences of any that do occur.

R&D Challenge: *Aircraft Fire Safety* - Develop standards and specifications for fire-resistant materials used in aircraft.

Fire, whether in-flight or as the result of a crash, can lead to many casualties in cases that would otherwise have been a survivable event. Rigorous, but practical, test criteria must be applied to all materials on aircraft, accompanied by rules and a comprehensive aircraft fire knowledge-base to support reduction of ignition sources and provide effective fire detection and suppression systems.

R&D Strategies:

1. Develop materials and standards to reduce the likelihood of ignition of aircraft fires and the severity and toxicity fires that do occur in flight and as a result of crashes. Evaluate ultra-

fire-resistant materials to eliminate burning cabin materials as a cause of death in aircraft accidents.

2. Develop improved fire detection and fire suppression systems. Develop technologies, procedures, test methods, and criteria for preventing accidents caused by hidden in-flight fires through improved fire detection and suppression systems and interior materials fire test methods and criteria.

Performance Objective: Increase crash survivability by enhancement of aircraft crashworthiness and evacuation practices.

R&D Challenge: *Aircraft Crashworthiness and Crash Survival* - Develop knowledge, tools, and standards to improve the crashworthiness of aircraft structures and systems and the effectiveness of evacuation procedures.

If fire is adequately controlled, aircraft crash situations can sometimes be survivable for many or even all occupants. However, this will depend to a large degree on crashworthiness of the aircraft structure, including interior elements, such as the passenger seats, and the effectiveness of evacuation procedures. FAA certification and guidance to industry are key means to assure that full advantage is taken of new materials and manufacturing processes. Similar considerations apply to assuring that aircraft design and configuration, as well and cabin crew training, rapid and safe evacuation capabilities and post-evacuation actions.

R&D Strategies:

1. Conduct tests and analyses and develop standards to guide design and manufacture of aircraft structures, cabin interiors, auxiliary fuel tank systems, and occupant seat and restraint systems with improved crashworthiness.

2. Develop knowledge, design, procedural guidelines, and recommendations for safe evacuation routes through various aircraft cabin configurations, particularly addressing designs for the very large aircraft now being planned.

Performance Objective: Increase crash survivability by enhancing the effectiveness of airport crash response capabilities.

R&D Challenge: *Airport Crash Response Capabilities* - Develop knowledge, tools, standards, information and guidance to support regulatory actions and improved operational practices related to post-crash response to accidents, particularly for the large aircraft now being planned.

The survivability of crashes or other incidents occurring on the airport surface can depend on the speed and effectiveness of airport rescue and firefighting actions. Planned new aircraft with multiple levels and high-density seating will complicate this process. FAA information, guidance, and regulatory actions in this area are important in influencing the equipment, facilities, training (including simulators), and practices employed.

R&D Strategy:

Develop knowledge, tools, and standards to improve airport rescue and fire-fighting efforts. Test and evaluate improved firefighting systems for use in controlling both external and internal cabin fires, and develop new methods, procedures, and firefighting chemicals to fight fires in future larger aircraft that will use advanced materials, such as carbon-based composites.

Derived Goal: Prevent successful attacks on the integrity and availability of critical NAS information systems as well as providing protection to FAA administrative and support systems.

Performance Objective: Protect the NAS and supporting information infrastructure systems against current and future cyber threats, detect and respond to those threats, and assure that those systems can be reconstituted quickly if necessary.

R&D Challenge: *Protection of Information Infrastructure* - Develop the technical foundation for incorporation of high-performance cybersecurity technology and procedures into the existing NAS and at the design level for new NAS elements.

Assurance of the integrity of FAA information systems and data, and the availability of service, are central to carrying out the agency's mission. Ever more serious threats are being developed, requiring more robust system defenses. Reduction of the vulnerability of the NAS and its users, as well as protection of FAA's administrative and support systems, requires that solutions be found to extraordinarily difficult technical problems. Further, as NAS modernization proceeds and the system continues to evolve, within an overall information technology context that is also continually changing, it is critical to guard against the possibility of vulnerabilities being created in the implementation of new or revised software and systems. Use of the Global Positioning System, for example, introduces a new and critical element of potential risk. New mechanisms must be developed to address both insider and outsider threats and vulnerabilities to key information systems.

R&D Strategies:

1. Develop and deploy improved technology for intrusion protection, detection, response, and recovery capabilities of critical information systems, focusing on a rapidly evolving threat base, achieving minimal false alarms, and guaranteeing continuity of service while under denial-of-service attacks.

2. Develop and incorporate new architectural approaches and improved cybersecurity capabilities into the NAS design and modernization process to assure continual protection. Develop architectural approaches to insure that, as the NAS evolves, the most vulnerable points in the very large and complex FAA information infrastructure are protected. Develop public key infrastructure technologies and procedures to enable secure transactions over public and other networks.

3. Develop and evolve technologies to enhance integrity and confidentiality in the mobile environment. As NAS systems evolve towards more autonomous digital control and communications, new techniques must be developed to address improved integrity and confidentiality in the dynamic and mobile environment created by digital wireless communications in both wide and local area environments.

4. Undertake collaborative R&D efforts with DoD, NSF, NASA, other organizations and industry to identify new and emerging technologies that can be employed to reduce the risks to the integrity and availability of critical systems and data. It is understood that effective protection in the evolving networked environments that will exist in the future can only be obtained by close collaborative and timely communication of existing threat and attack information while addressing the impacts of security actions on organic and non-organic IT resources.

5. Conduct research necessary to enhance the protection of GPS from unintentional or intentional interference, including development of improved interference direction-finding equipment and appropriate studies to further define the problem, assess impacts, and identify and characterize protection and mitigation strategies.

Derived Goal: Prevent adverse health impacts on air passengers and flight crews.

Performance Objective: Identify and reduce adverse health impacts associated with the cabin environment.

R&D Challenge: *Cabin Environment Health Impacts* - Develop understanding of health risks in the cabin environment sufficient to assess the need for remedial actions and provide the scientific basis for developing them.

A variety of threats to the health of passengers and flight crews can exist in the cabin environment, including poor cabin air quality, sudden decompression, and, for very high altitude flights, cosmic radiation. In general, these possible hazards are difficult to assess quantitatively to determine the reality and magnitude of the threat and the preferred means of addressing it.

R&D Strategy:

Develop knowledge, recommendations, and guidelines to minimize health risks to cabin occupants and aircraft crews and assure health maintenance of cabin occupants with respect to possible hazards, including poor air quality, cosmic and other radiation, and sudden decompression.

System Efficiency

Derived Goals

The FAA efficiency goal is to provide an aerospace transportation system that meets the needs of the users and is efficient in the application of FAA and aerospace resources. This goal requires

that a proper balance be achieved among three NAS attributes: level of service to the user community; costs to the users, insofar as they are affected by NAS performance and capabilities; and costs incurred by the FAA in providing those services. The first component of this objective matches the focus of the OEP-- meeting the basic service needs of users of the NAS by providing sufficient system capacity to prevent significant user delays, and greatly reducing the impact of adverse weather on operations. Minimization of the NAS-related costs to users requires increasing the predictability of NAS performance and increasing the operational flexibility offered NAS users. Finally, the agency is charged with minimizing the cost of providing the NAS infrastructure and operating the system. A key role of System Efficiency R&D is to explore and support the introduction of existing technologies into the aviation system. The complex and demanding requirements associated with aviation applications can require extensive R&D efforts to assure successful, timely and safe innovation.

The three System Efficiency Derived Goals are:

- ***Match system capacity to the traffic demands of users of the NAS.***
- ***Minimize the costs to users of the NAS.***
- ***Reduce the cost of providing NAS infrastructure and operations.***

Performance Objectives, Challenges, and R&D Strategies

Derived Goal: Match system capacity to the traffic demands of users of the NAS.

Performance Objective: Provide sufficient airport arrival/departure capacity to meet demand.

R&D Challenge: *Increased Airport Arrival/Departure Rates* - Develop and evaluate technologies, practices, and operational procedures that support accelerated design and construction of runways and full exploitation of their capacity.

Many of the busiest airports currently are unable to meet peak arrival/departure demand; future growth in aviation activity will exacerbate this situation. By itself, construction of new runways is unlikely to resolve this problem. Expanded runway capacity must be accompanied by improvements in airspace design, technology, decision support aids, procedures, and standards to make the fullest possible use of available runway and other surface infrastructure.

R&D Strategies:

1. Facilitate surface infrastructure design, construction practices, and efficient operational surface movement.

2. Provide terminal airspace standards, procedures, and tools that support improved terminal airspace and route design and permit full use of available runway capacity.

Performance Objective: Provide sufficient en route capacity to meet demand.

R&D Challenge: *Increased En Route Capacity* - Develop operational concepts, standards, and tools that increase flexibility in responding to changing circumstances and better matching airspace design and capacity and demand.

When demand exceeds capacity in one or several sectors, the resulting congestion can quickly affect other airspace, sometimes leading to near-gridlock conditions. Increases in physical capacity and reductions in controller workload are critical to providing the flexibility needed to prevent congestion from arising, and to respond quickly and effectively to that which does occur.

R&D Strategies:

1. Develop tools and analyses to design and evaluate airspace design and reduce separation standards without compromising safety.

2. Develop tools and validate procedures for strategic collaborations between users and providers to resolve tactical congestion problems.

3. Develop and validate improved controller-pilot communication technologies.

4. Develop human-machine interface and system-to-system coordination to support controller-to-controller communication, improved planning and reduce uncertainty through increased current and future situational awareness.

Performance Objective: Minimize adverse impacts of adverse airport weather conditions on operational capacity.

R&D Challenge: *Reduced Airport Weather Impacts* - Develop and evaluate technologies, tools, and procedures to achieve near optimum runway acceptance rates without regard for meteorological conditions.

Airport arrival and departure rates can be lowered substantially under adverse weather conditions, by limiting the use of runways and increasing spacing between flights. Cockpit tools and enhanced navigation aids could extend the range of conditions under which visual operations can be conducted.

R&D Strategies:

1. Develop and validate new NAS services, based on surveillance and navigation technologies and procedural improvements, to enable continued arrival operations as weather deteriorates from visual meteorological conditions (VMC) to instrument meteorological conditions (IMC).

2. Validate new cockpit tools and displays to achieve VMC throughput capacity in all weather conditions.

3. Develop and evaluate tools and procedure, and improved weather prediction capabilities to

facilitate efficient runway reconfiguration at the onset and conclusion of hazardous weather conditions.

Performance Objective: Minimize adverse impacts of en route severe weather conditions on operational capacity.

R&D Challenge: *Reduced En Route Weather Impacts* - Develop and evaluate the means to generate and deliver more specific and timely weather information to users, and the means for providers and users to respond effectively and rapidly to hazardous weather.

Adverse en route weather can block access to key sectors and shift traffic in ways that create new congestion points. The result is significant reduction of the capacity of portions of the system, with delays and service cancellations quickly spreading across the nation. When the system is already operating at a point near capacity, poor en route conditions can produce a dramatic reduction in the overall level of service and efficiency of the NAS. Severe weather cannot be prevented, but provision of comprehensive, accurate, location-specific, and timely predictions can enable airlines, aircrews, controllers, and airline dispatchers to work together to develop and implement more effective tactics and strategies for dealing with weather events.

R&D Strategy:

1. Develop means for improved weather prediction and timely dissemination to all aerospace system users.

2. Develop means for greater integration of common weather information into the air traffic management process, including collaborative adjustment of routes.

Performance Objective: Expand NAS services in areas lacking Air Traffic Control (ATC)/Air Traffic Management (ATM) infrastructure.

R&D Challenge: *Expanded Access and Service Availability* - Develop and validate technologies to enable instrument approaches at remote and low-traffic airports.

Improvement of the NAS level of service may offer limited benefit to those who live in relatively remote or low population-density regions and, thereby, are unable to access the system because of a an economically-driven lack of infrastructure (radar, approach systems, etc.). Technology advances offer the possibility of significantly broadening the availability of NAS services.

R&D Strategy:

Develop alternatives to fixed terrestrial facilities as a means of rapidly introducing improved NAS services in remote areas.

Performance Objective: Identify and develop capacity enhancements that will meet the post-2010 needs of users.

R&D Challenge: *Future Capacity Enhancements* – Explore and apply system architectural concepts, technologies, and procedures that will make possible NAS capacity increases sufficient to meet traffic demand beyond 2010.

Long-term growth of air transportation will require not only that current capacity limitations be eliminated, but also that performance of the system be continually enhanced to accommodate the projected expansion of aviation activity and associated demand for NAS services. This will pose a very demanding challenge requiring implementation of system architecture responsive to evolving patterns of user needs and operational strategies, availability of increasingly powerful technology options, and development of innovative ways of operating the airspace system. This endeavor will require close collaboration with the aviation and technology communities.

R&D Strategy:

1. Develop a NAS architecture to serve as the framework for a flexible and adaptable air traffic management system that (a) is based on the paradigm of timely and efficient delivery information to all actors; (b) can rapidly and efficiently be reconfigured in response to changing user needs and patterns of operation; (c) facilitates evolutionary incorporation of technology improvements and innovations; and (d) fosters exploration and validation of alternative operational tools, procedures and strategies.

2. Undertake structured collaborations with NASA, other organizations, and the industry to identify air traffic management concepts and provide technical analyses and evaluations to guide their incorporation into the NAS and accelerate exploitation of new technologies required to enable those concepts.

Derived Goal: Minimize the costs to users of the NAS.

Performance Objective: Increase the predictability of NAS performance.

R&D Challenge: *Improved NAS Predictability* - Provide users with improved current and projected status information in an operational environment.

When congestion and delays upset airline schedules, the process of adjusting (e.g., through cancellation of flights) can be costly, especially if the disruption is widespread and lengthy. The consequences of these events can be reduced by communicating to all users accurate and timely system status information and the projections they need to make timely adjustments to their plans and implement collaborative solutions.[9]

R&D Strategies:

1. Identify, develop, and validate improved technology and processes for communication to users of current and projected NAS status and performance. Demonstrate and validate

[9] The predictability Performance Objective will also be supported by all of the activities undertaken to achieve the Derived Goal of maximizing the level of providing system capacity to match traffic demand.

advanced technology and procedures in an operational environment to accelerate their application to provide NAS users with highly specific and accurate indications of current status and any projected constraints or uncertainties.

2. Identify and develop tools for knowledge capture of operational experience with respect to actual performance and decisions made in order to support post-analysis that will facilitate lessons learned, improved training and repeatability of "best practices," and longer–term strategic planning.

Performance Objective: Increase system flexibility to allow users to adapt operations to changing conditions.

R&D Challenge: *Greater NAS Flexibility* - Validate performance and safety of technologies critical to implementation of Free Flight.

The concept of Free Flight, in which operators have the freedom to select their path and speed in real time, will permit much greater flexibility for airlines and FAA controllers in maximizing use of available airspace and responding to adverse weather or other factors that constrain capacity and predictability. Significant cost benefits for users are expected to result, as well as other operational advantages. Realization of Free Flight and full exploitation of its potential will require extensive evaluation efforts to validate alternative strategies and procedures.

R&D Strategies:

1. Accelerate application of specific CNS technologies critical to Free Flight and related procedures that enhance user flexibility.

2. Demonstrate and validate advanced technologies and procedures in an operational environment to accelerate the implementation of capabilities that expand the operational freedom of users and involve them in setting system strategies.

Derived Goal: Reduce the cost of providing NAS infrastructure and operations.

Performance Objective: Enhance the operational reliability and reduce the life-cycle cost of the infrastructure that supports provision of all NAS services.

R&D Challenge: *Reduction of the Cost of Providing NAS Services* - Design and evaluate infrastructure technologies that minimize life-cycle costs, and develop tools to accelerate the development of software systems.

A major portion of the cost of providing NAS services is associated with ongoing investment in system modernization and evolutionary upgrades, and with maintenance of installed facilities and equipment. Minimization of these costs can be achieved only by incorporating analyses of life-cycle costs in the design of system elements. Control of the cost of software development is a particularly important consideration, requiring development and tools for efficient and effective construction of NAS systems based on the new architectures.

R&D Strategies:

1. Perform analyses and design subsystems for implementation in the NAS infrastructure that fully incorporate consideration of costs of initial construction and deployment, operations, repair, and maintenance, and workforce requirements.

2. Develop means for ensuring that Commercial Off-The-Shelf (COTS) software is safe and will function as required, including identifying and developing practices for safety-related systems using COTS software.

3. Develop software design and development tools and techniques to enable more efficient management and accelerated deployment of key NAS software systems using reusable and common components for a new FAA standards-based architecture.

4. Develop new verification and validation techniques that will increase overall system quality while reducing the time and costs associated with existing methods.

Performance Objective: Reduce the cost and improve the life of airport pavement, and increase capacity, operational and functional efficiency, and groundside access of airports.

R&D Challenge: *Reduction of Airport Surface and Terminal Infrastructure Cost* - Develop guidance and standards for pavement design and construction and airport design and layout.

Very substantial public funds from the Airports and Airways Trust Fund are invested in airport construction and improvements, particularly for runways and other pavements. The functional demands on airport pavements are substantially different from the highway situation, posing unique technical issues. Airport design and layout can be a critical factor in efficient operation and in ability to respond to changing patterns of use.

R&D Strategy:

Collect operational data and conduct analyses to support development of guidelines and standards relating to pavement design and construction, airport and terminal design and layout, including consideration of changing fleet mix (new large aircraft, regional jets, etc.), and integration of ground transportation linkage. These R&D products will contribute significantly to reduced costs and less interference of construction with airport operations.

Environment

Derived Goals

The FAA enabling goal for environment is to prevent, minimize, and mitigate adverse environmental impacts associated with aviation activity. Aircraft and airport operations affect the environment in many ways. Public concerns over the environmental affects of aircraft and airport operations, as well as those requirements embodied in laws and regulations, can severely constrain the ability of the aviation system to meet the nation's need for mobility and economic growth.

The nature of environmental impacts, and the means by which they can be reduced or eliminated, generally involve complex and multi-disciplinary science, and draw on a wide range of operational and technology choices. Effective and practical FAA environmental programs and actions require a sophisticated understanding of specific aerospace-related environmental issues and the development of tools to characterize accurately those impacts. It is then necessary to apply that understanding to the control and reduction of environmental impacts of aircraft and airport operations.

The FAA also has a responsibility to quantify and mitigate environmental impacts of its facilities and activities. However, at present this imperative is being met through known technologies and practices, and does not imply a significant need for research and development. It is therefore not included as a Derived Goal in this strategic framework.

There are two Derived Goals for Environment:

- ***Increase understanding of current and potential environmental consequences of aviation-system operation and alternative countermeasures.***
- ***Control and reduce environmental impacts of aircraft and airport operations.***

Performance Objectives, Challenges, and R&D Strategies

Derived Goal: Increase understanding of current and potential environmental consequences of aerospace system operation and alternative countermeasures.

Performance Objective: Characterize and assess aviation environmental impacts and countermeasures.

R&D Challenge: *Enhanced Knowledge Base* - Enhance the knowledge base and array of planning tools available for designing and implementing programs to reduce environmental impacts.

Improved analytic and planning tools are necessary to achieving a better understanding of aviation's environmental impacts, and providing insight into the consequences of alternative courses of action. Enhanced analytical tools and simulation models must accompany improved

understanding of relevant physical, chemical, and biological processes if impacts are to be accurately characterized and effective and efficient countermeasures designed and implemented. Noise certification stringency needs to be increased as technology allows. At present, noise and air quality impacts in the vicinity of airports are the primary area of concern. However, the very broad issue of global climate change also must be addressed, and possible impacts associated with commercial space transportation operations may also require focused R&D.

R&D Strategy:

Develop and validate methodologies and models to assess aircraft-related noise exposure, aviation emissions and impact on air quality, and greenhouse gas emissions. The capability to estimate the effect of operational and technology changes, as well as introduction of specific countermeasures, is central to FAA decisions relating to aerospace environmental impacts. Thus, development of comprehensive and validated computer models and application data is an essential component of meeting FAA responsibilities with respect to aircraft noise, air quality impacts, and contribution to production of greenhouse gases. These tools are also needed by the aviation community to support environmental assessments.

Derived Goal: Control and reduce environmental impacts of aircraft and airport operations.

Performance Objective: Minimize aviation noise impacts on the population.

R&D Challenge: *Minimization of Noise Impacts* - Develop, apply and disseminate knowledge and tools to support international harmonization and optimization of the mix of noise-related aircraft certification standards, operational procedures and abatement technology.

In many locations, control and reduction of terminal-area noise is the major environmental issue limiting the efficiency and growth of air transportation. The scientific assessment and development of safe and affordable options for mitigating the impacts of aircraft noise are important not only to protect the environment, but also to sustain the continued expansion of air transportation. FAA efforts to address this complex issue include creating a cooperative development effort that balances noise reduction with adequate airport capacity, managing FAA activities to understand and minimize adverse environmental consequences, stimulating private industry and government research to reduce noise created by the aviation sector, and harmonizing international aircraft noise certification standards.

R&D Strategies:

1. Develop data, requirements, standards, rules, and technical guidance addressing certification of new and modified designs for reduction of aircraft noise.

2. Prepare technical documentation and training materials for use by aircraft manufacturers and others.

3. Provide computer models and impact criteria for use by civil aviation authorities in

environmental assessments. These activities provide the technical basis for internationally harmonized noise certification regulations.

Performance Objective: Minimize the impact of aviation engine emissions.

R&D Challenge: *Minimization of Air Quality Impacts* - Develop, apply, and disseminate knowledge and tools to support international harmonization and optimization of the mix of emissions-related aircraft certification standards, certification test procedures, and abatement technology.

Emissions from aircraft engines and airport operations, including generation of carbon dioxide and other greenhouse gases, is a rising challenge for the aviation community and, just as is the case for noise, could impose a significant limit on the growth and performance of the air transportation system. The scientific assessment and development of safe and affordable options for mitigating the impacts of aircraft engine emissions are necessary to address this concern. Additionally, to understand and minimize adverse environmental consequences, a knowledge base and effective tools are needed to reduce emissions by the aviation sector and to harmonize international engine emissions certification standards.

R&D Strategies:

1. Develop data, requirements, standards, rules, and technical guidance addressing certification of new and modified designs for reduction of aircraft emissions.

2. Prepare technical documentation and training materials for use by aircraft manufacturers and others.

3. Provide computer models and impact criteria for use by civil aviation authorities in environmental assessments. These activities provide the technical basis for internationally harmonized engine emission certification regulations.

Summary

The R&D Challenges and Strategies described above are summarized in the following table.

Safety

R&D Challenges	R&D Strategies
Derived Goal: Reduce the occurrence of aviation system accidents caused by new or previously unrecognized causal factors.	
Safety Information Sharing and Analysis *- Develop and apply data and analytical tools for use by FAA and industry in identifying potential accident causes and developing effective safety programs and countermeasures.*	(1) Develop and apply data systems and risk management and decision support tools and methodologies to monitor and analyze aviation system operations and safety risks. (2) Develop broadened understanding of biomedical, toxicological, and human performance factors that can contribute to accidents.

System Safety and Risk Management *- Develop and apply knowledge and analytical tools to assess the safety implications of innovative technologies and operational procedures planned or proposed for implementation in the airspace system.*	(1) Develop tools to support the creation and introduction of high confidence software and systems in safety-critical NAS functions and aircraft avionics. (2) Assess and address the safety implications of new composites, alloys and other materials, and associated structures and fabrication techniques. (3) Assess and develop responses to the safety implications of evolving operational procedures and practices, including measures to enhance aviation security.
Derived Goal: Reduce the recurrence of aviation system accidents due to known risks or causal factors.	
Hazards of the Flight Environment *- Characterize potential hazards of the flight environment and develop the knowledge base and technologies needed to eliminate or reduce those hazards.*	(1) Improve understanding, predictability and ability to deal with adverse weather, icing conditions, and other atmospheric hazards, and improve the delivery of weather products to pilots and aircrews. (2) Develop guidance concerning flight hazards associated with electromagnetic fields.
Failures of Aircraft Structures and Systems *- Develop knowledge, criteria, tools, technologies, and practices to improve reliability and prevent or reduce failures of aircraft structures systems.*	(1) Develop improvements in aircraft fuel tank explosion protection. (2) Develop knowledge, inspection tools, techniques, and strategies to address safety hazards associated with the aging of airframe structures, engine components, and mechanical and electrical systems. (3) Assess the use of improved processing and manufacturing techniques for critical engine components to eliminate engine failures (4) Assess the use of advanced materials protect aircraft critical systems and passengers in the event of catastrophic engine failures. (5) Assess the safety implications of changes to aviation fuels used for both commercial and general aviation.
Human Performance *- Develop knowledge, guidance, and standards to improve the performance and to structure the roles and working environments of the people who play critical roles in aviation safety.*	Develop knowledge, guidance and standards for: (1) Design and use of automated support systems. (2) Personnel selection and training. (3) Human performance assessment. (4) Information management and display. (5) Bioaeronautical factors.
Terminal Area Safety *- Develop technologies and evaluate strategies to increase pilot and controller situational awareness in the terminal area, reduce wildlife interactions, and assure compatibility of airport designs and infrastructure with new types of aircraft.*	(1) Develop technology and standards to increase pilot and controller awareness of potential runway incursions and other hazards. (2) Conduct evaluations and assessments of means to reduce bird-strike and other wildlife-related risks. (3) Conduct tests and analyses to assure compatibility of airport design with new larger aircraft.
Safety of Reusable Launch Vehicles *- Determine best practices for commercial space transportation operations, develop criteria for assessing the safety of RLVs.*	(1) Identify commercial space transportation operations best practices. (2) Establish criteria to define a "proven" RLV. (3) Assess effects of RLV maneuverability characteristics on public safety.
Derived Goal: Increase the survivability of aviation system accidents.	
Aircraft Fire Safety *- Develop standards and specifications for fire-resistant materials used in aircraft*	(1) Develop materials and standards to increase aircraft fire resistance. (2) Develop improved fire detection and fire suppression systems.
Aircraft Crashworthiness and Crash Survival *- Develop knowledge, tools, and standards to improve the crashworthiness of aircraft structures and systems and the effectiveness of evacuation procedures.*	(1) Develop knowledge, tools, and standards to improve the crash characteristics of aircraft structures and systems. (2) Develop knowledge, design and procedural guidelines to enhance the effectiveness, speed, and safety of aircraft evacuation.

Airport Crash Response Capabilities *- Develop knowledge, tools, standards, information, and guidance to support regulatory actions and improved operational practices related to post-crash response to accidents.*	(1) Develop knowledge, tools, and standards to improve airport rescue and fire-fighting efforts. (2) Test and evaluate improved firefighting systems for use in controlling both external and internal cabin fires, and develop new methods, procedures, and chemicals to fight fires in future aircraft that use advanced materials.

Derived Goal: Prevent successful attacks on the integrity and availability of critical NAS information systems.

Protection of NAS Information Infrastructure *- Develop the technical foundation for incorporation of high-performance cybersecurity technology and procedures into the existing NAS and at the design level for new NAS elements.*	(1) Develop high-performance intrusion protection, detection and response capabilities for incorporation into the NAS. (2) Develop and incorporate into the NAS architectural approaches and improved cybersecurity capabilities design and modernization process. (3) Develop and evolve technologies to enhance integrity and confidentiality of communications in the mobile environment. (4) Undertake collaborative R&D with DoD, NSF, NASA, and others to identify new and emerging technologies that can be employed to reduce the risks to the integrity and availability of critical systems and data. (5) Conduct research to enhance the protection of GPS from unintentional or intentional interference.

Derived Goal: Prevent adverse health impacts on air passengers and flight crews

Cabin Environment Health Impacts *- Develop understanding of health risks in the cabin environment sufficient to assess the need for remedial actions and provide the scientific basis for developing them.*	Develop knowledge, recommendations, and guidelines to minimize health risks to cabin occupants and aircraft crews and assure health maintenance of cabin occupants with respect to possible hazards, including poor air quality, cosmic and other radiation, and sudden decompression.

Efficiency

R&D Challenges	*R&D Strategies*
Derived Goal: Match system capacity to the traffic demands of users of the NAS.	
Increased Airport Arrival/Departure Rates *– Develop and evaluate technologies, practices, and operational procedures that support accelerated design and construction of runways and full exploitation of their capacity.*	(1) Facilitate surface infrastructure design, construction practices, and efficient operational surface movement. (2) Provide terminal airspace standards, procedures, and tools that support improved terminal airspace and route design and permit full use of available runway capacity.
Increased En Route Capacity *- Develop operational concepts, standards, and tools that increase flexibility in responding to changing circumstances and better matching airspace design and capacity and demand.*	(1) Develop tools and analyses to design and evaluate airspace design and reduce separation standards without compromising safety. (2) Develop tools and validate procedures for strategic collaborations between users and providers to resolve tactical congestion problems. (3) Develop and validate improved controller-pilot communication technologies.

Reduced Airport Weather Impacts *- Develop and evaluate technologies, tools, and procedures to achieve near optimum runway acceptance rates without regard for meteorological conditions.*	(1) Develop and validate new services, based on surveillance and navigation technologies and procedural improvements, to enable continued arrival operations as weather deteriorates from visual to instrument meteorological conditions. (2) Validate new cockpit tools and displays to achieve VMC throughput capacity in all weather conditions. (3) Develop and evaluate tools and procedure, and improved weather prediction capabilities to facilitate efficient runway reconfiguration at the onset and termination of hazardous weather conditions.
Reduced En Route Weather Impacts *- Develop and evaluate means to generate and deliver more specific and timely weather information to users, and means for providers and users to respond effectively and rapidly to hazardous weather.*	(1) Develop means for improved weather prediction and timely dissemination to all aerospace system users. (2) Develop means for greater integration of common weather information into the air traffic management process, including collaborative adjustment of routes.
Expanded Access and Service Availability *- Develop and validate technologies to enable instrument approaches at remote and low-traffic airports.*	Develop alternatives to fixed terrestrial facilities as a means of rapidly introducing improved NAS services in remote areas.
Future Capacity Enhancements *– Explore and apply concepts, technologies and procedures that will make possible NAS capacity increases sufficient to meet traffic demand beyond 2010.*	(1) Develop a NAS architecture to serve as the framework for a flexible ATM that is based on the paradigm of timely and efficient delivery information to all actors, can readily be reconfigured in response to changing patterns of operation, facilitates evolutionary improvement, and fosters exploration of alternative procedures and strategies. (2) Undertake structured collaborations with NASA and others to identify improved ATM concepts and foster their incorporation into the NAS.
Derived Goal: Minimize the costs to users of the NAS.	
Improved NAS Predictability *- Provide users with improved current and projected status information in an operational environment*	(1) Identify, develop and validate improved technology and processes for communication to users of current and projected NAS status and performance. (2) Identify and develop tools for knowledge capture of operational experience with respect to actual performance and decisions made to support post-analysis that facilitates lessons learned, improved training and repeatability of "best practices," and longer–term strategic planning.
Greater NAS Flexibility *-Validate performance and safety of technologies critical to implementation of Free Flight.*	(1) Accelerate application of CNS technologies critical to Free Flight. (2) Demonstrate and validate advanced technologies in an operational environment to accelerate availability of capabilities that involves users and removes operational constraints.
Derived Goal: Reduce the cost of providing NAS infrastructure and operations.	
Reduction of the Cost of Providing NAS Services *- Design and evaluate infrastructure technologies that minimize life-cycle costs, and develop tools to accelerate the development of software systems.*	(1) Perform analyses and design NAS subsystems that reflect costs of deployment, operations, repair and maintenance, and workforce needs. (2) Develop means for ensuring that Commercial Off-The-Shelf (COTS) software is safe and will function as required. (3) Develop tools and techniques for efficient development and deployment of NAS software systems.
Reduction of Airport Surface and Terminal Infrastructure Cost *- Develop guidance and standards for pavement design and construction and airport design and layout.*	Collect operational data and conduct analyses to support development of guidance and standards for pavement design and construction and airport design and layout.

Environment

R&D Challenges	R&D Strategies
Derived Goal: Increase understanding of current and potential environmental consequences of aviation-system operations, and alternative countermeasures.	
Enhanced Knowledge Base *- Enhance the knowledge base and array of planning tools available for designing and implementing programs to reduce environmental impacts.*	Develop and validate methodologies and models to assess aircraft noise exposure, aviation emissions and impact on air quality, and greenhouse gas emissions.
Derived Goal: Control and reduce environmental impacts of aircraft and airport operations.	
Minimization of Noise Impacts *- Develop, apply and disseminate knowledge and tools to support international harmonization and optimization of noise-related aircraft certification standards, operational procedures and abatement technology.*	(1) Develop data, requirements, standards, rules, and technical guidance addressing certification of new and modified designs for reduction of aircraft noise. (2) Prepare technical documentation and training materials for use by aircraft manufacturers and others. (3) Provide computer models and impact criteria for use by civil aviation authorities in environmental assessments.
Minimization of Air Quality Impacts *- Develop, apply, and disseminate knowledge and tools for international harmonization and optimization of emissions-related aircraft certification standards, test procedures, and abatement technology.*	(1) Develop emission reduction data, requirements, standards, rules, and technical guidance for certification of new and modified designs. (2) Prepare technical documentation and training materials for use by aircraft manufacturers and others. (3) Provide computer models and impact criteria for use by civil aviation authorities in environmental assessments.